

Wonsuk Cha

X-ray Science Division
Advanced Photon Source
Argonne National Laboratory
9700 S. Cass Ave.
Argonne, IL 60439, USA

Office: +1-630-252-1627
E-mail: wcha@aps.anl.gov

■ Research Interests

My research focuses on discovering the relationship between structure and property using and developing new coherent x-ray diffraction techniques.

- Revealing structure/property relationships in nanomaterials with in-situ coherent x-ray diffraction imaging by examining deformation field distributions
- Utilizing broadband coherent x-rays for fast measurements for coherent x-ray diffraction imaging in Bragg geometry
- Investigating atomic structure of thin films with x-ray scattering techniques, such as grazing incidence small angle scattering and x-ray reflectivity
- Developing new instruments for in-situ catalysis or phase transition experiments

■ Employment

2016-Present	Assistant Physicist	X-ray Science Division, Advanced Photon Source, Argonne National Laboratory, USA
2014-2016	Postdoctoral Appointee	Materials Science Division, Argonne National Laboratory, Argonne, USA

■ Education

2014	Ph. D	Physics, Sogang University, Seoul, Korea Thesis: “Coherent X-ray Diffraction Imaging on Zeolite Microcrystals” Advisor: Prof. Hyunjung Kim
2009	M. S.	Engineering (Interdisciplinary Program of Integrated Biotechnology), Sogang University, Seoul, Korea Thesis: “Deformation Field Mapping of Zeolite Microcrystals by Coherent X-ray Diffraction” Advisor: Prof. Hyunjung Kim
2007	B. S.	Physics and Mathematics, Sogang University, Seoul, Korea

■ Professional Activities

2017	Chair of Gordon Research Seminar in X-ray Science
2017	Journal reviewer of Review of Scientific Instruments

■ Publications (Submission/Preparation)

1. Sanghoon Song, Wonsuk Cha, Sanghyeok Jo, Hyun-jun Park, Jinback Kang, Gongjun Choi, Zhang Jiang, Suresh Narayanan, Hyunjung Kim, Surface dynamics in mixture thin film of homopolymer and diblock copolymer near the order-disorder phase transition, in preparation.

■ Publications

1. Wonsuk Cha, Yihua Liu, Hoydoo You, Gregory Brian Stephenson, and Andrew Ulvestad, Dealloying in Individual Nanoparticles and Thin Film Grains: A Bragg Coherent Diffractive Imaging Study, Accepted by *Advanced Functional Materials*.
2. Allison Yau, Wonsuk Cha, Matthew W. Kanan, G. Brian Stephenson, Andrew Ulvestad, Bragg coherent diffractive imaging of single-grain defect dynamics in polycrystalline films, *Science* **358**, 739-742 (2017).
3. Y. Liu, P. P. Lopes, W. Cha, R. Harder, J. Maser, E. Maxey, M. J. Highland, N. M. Markovic, S. O. Hruszkewycz, G. B. Stephenson, H. You, and A. Ulvestad, Stability Limits and Defect Dynamics in Ag Nanoparticles Probed by Bragg Coherent Diffractive Imaging, *Nano Letters* **17**, 1595-1601 (2017).
4. S. O. Hruszkewycz, W. Cha, P. Andrich, C. P. Anderson, A. Ulvestad, R. Harder, P. H. Fuoss, D. D. Awschalom, and F. J. Heremans, In situ study of annealing-induced strain relaxation in diamond nanoparticles using Bragg coherent diffraction imaging, *APL Materials* **5**, 026105 (2017).
5. A. Ulvestad, M. J. Welland, W. Cha, Y. Liu, J. W. Kim, R. Harder, E. Maxey, J. N. Clark, M. J. Highland, H. You, P. Zapol, S. O. Hruszkewycz and G. B. Stephenson, Three-dimensional imaging of dislocation dynamics during the hydriding phase transformation, *Nature Materials* **16**, 565-571 (2017).
6. Mathew J. Cherukara, Kiran Sasikumar, Wonsuk Cha, Badri Narayanan, Steven J. Leake, Eric M. Dufresne, Tom Peterka, Ian McNulty, Haidan Wen, Subramanian K. R. S. Sankaranarayanan, and Ross J. Harder, Ultrafast Three-Dimensional X-ray Imaging of Deformation Modes in ZnO Nanocrystals, *Nano Letters* **17**, 1102-1108 (2017).
7. W. Cha, A. Ulvestad, M. Allain, V. Chamard, R. Harder, S. J. Leake, J. Maser, P. H. Fuoss, and S. O. Hruszkewycz, Three Dimensional Variable-Wavelength X-Ray Bragg Coherent Diffraction Imaging, *Physical Review Letters* **117**, 225501 (2016).
8. Hyo-Sang Lee, Joong Suk Lee, A-Ra Jung, Wonsuk Cha, Hyunjung Kim, Hae Jung Son, Jeong Ho Cho, BongSoo Kim, Processing temperature control of a diketopyrrolopyrrole-alt-thieno[2,3-b]thiophene polymer for high-mobility thin-film transistors and polymer solar cells with high open-circuit voltages, *Polymer* **105**, 79-87 (2016).
9. Wonsuk Cha, Wenjun Liu, Ross Harder, Ruqing Xu, Paul H. Fuoss, Stephan O. Hruszkewycz, Utilizing broadband x-rays in a Bragg coherent x-ray diffraction imaging experiment, *Journal of Synchrotron Radiation* **23**, 1241-1244 (2016).
10. A. Ulvestad, A. Tripathi, S. O. Hruszkewycz, W. Cha, P. H. Fuoss, S. M. Wild, G. B. Stephenson, Coherent diffractive imaging of time-evolving samples with improved temporal resolution, *Physical Review B* **93**, 184105 (2016).
11. Minwoo Jung, Dongkyun Seo, Kyungwon Kwak, Ajeong Kim, Wonsuk Cha, Hyunjung Kim, Youngwoon Yoon, Min Jae Ko, Doh-kwon Lee, Jin Young Kim, Hae Jung Son, BongSoo Kim, Structural and morphological tuning of dithienobenzodithiophene-core

- small molecules for efficient solution processed organic solar cells, *Dyes and Pigments* 115, 23-34 (2015).
12. Jong Yong Choi, Woonggi Kang, Boseok Kang, Wonsuk Cha, Seon Kyoung Son, Youngwoon Yoon, Hyunjung Kim, Youngjong Kang, Min Jae Ko, Hae Jung Son, Kilwon Cho, Jeong Ho Cho, and BongSoo Kim, High Performance of Low Band Gap Polymer-Based Ambipolar Transistor Using Single-Layer Graphene Electrodes, *ACS Applied Materials and Interfaces* 7, 6002-6012 (2015).
 13. Dahyun Nam, Jungcheol Kim, Jae-Ung Lee, Akira Nagaoka, Kenji Yoshino, Wonsuk Cha, Hyunjung Kim, In Chul Hwang, Kyung Byung Yoon, and Hyeonsik Cheong, Polarized Raman spectroscopy of Cu-poor and Zn-rich single-crystal $\text{Cu}_2\text{ZnSnSe}_4$, *Applied Physics Letters* 105, 173903 (2014).
 14. Do Hwan Kim, Jung Ah Lim, Wonsuk Cha, Jung Heon Lee, Hyunjung Kim, Jeong Ho Cho, Directed self-assembly of organic semiconductors via confined evaporative capillary flows for use in organic field-effect transistors, *Organic Electronics* 15, 2322-2327 (2014).
 15. Jerome Carnis, Wonsuk Cha, James Wingert, Jinback Kang, Zhang Jiang, Sanghoon Song, Marcin Sikorski, Aymeric Robert, Christian Gutt, San-Wen Chen, Yeling Dai, Yicong Ma, Hongyu Guo, Laurence B. Lurio, Oleg Shpyrko, Suresh Narayanan, Mengmeng Cui, Irem Kosif, Todd Emrick, Thomas P. Russell, Hae Cheol Lee, Chung-Jong Yu, Gerhard Grübel, Sunil K. Sinha and Hyunjung Kim, Demonstration of Feasibility of X-Ray Free Electron Laser Studies of Dynamics of Nanoparticles in Entangled Polymer Melts, *Scientific Reports* 4, 6017 (2014).
 16. Minwoo Jung, Youngwoon Yoon, Jae Hoon Park, Wonsuk Cha, Ajeong Kim, Jinback Kang, Sanjeev Gautam, Dongkyun Seo, Jeong Ho Cho, Hyunjung Kim, Jong Yong Choi, Keun Hwa Chae, Kyungwon Kwak, Hae Jung Son, Min Jae Ko, Honggon Kim, Doh-Kwon Lee, Jin Young Kim, Dong Hoon Choi, and BongSoo Kim, Nanoscopic Management of Molecular Packing and Orientation of Small Molecules by a Combination of Linear and Branched Alkyl Side Chains, *ACS Nano* 8, 5988-6003 (2014).
 17. Woonggi Kang, Minwoo Jung, Wonsuk Cha, Sukjae Jang, Youngwoon Yoon, Hyunjung Kim, Hae Jung Son, Doh-Kwon Lee, BongSoo Kim, and Jeong Ho Cho, High Crystalline Dithienosilole-Cored Small Molecule Semiconductor for Ambipolar Transistor and Nonvolatile Memory, *ACS Applied Materials and Interfaces* 6, 6589-6597 (2014).
 18. Chung-Jong Yu, Hae Cheol Lee, Chan Kim, Wonsuk Cha, Jerome Carnis, Yoonhee Kim, Do Young Noh, Hyunjung Kim, Coherent X-ray Scattering Beamline at the Port 9C of the Pohang Light Source II, *Journal of Synchrotron Radiation* 21, 264-267 (2014).
 19. Sanghyeok Cho, Wonsuk Cha, Hyun-jun Park, Jung-Min Lee, Eun-Bee Kim, Hee-Woo Rhee, Zhang Jiang, Joseph Strzalka, Hyunjung Kim, Effects of siloxane nanoparticles on glass transition temperature and crystallization in PEO-LiPF₆ polymer electrolytes, *Synthetic Metals* 177, 110-113 (2013).
 20. Wonsuk Cha, Nak Cheon Jeong, Sanghoon Song, Hyun-jun Park, Tung Cao Thanh Pham, Ross Harder, Bobae Lim, Gang Xiong, Docheon Ahn, Ian McNulty, Jungho Kim, Kyung Byung Yoon, Ian K Robinson, and Hyunjung Kim, Core-Shell Strain Structure of Zeolite Microcrystals, *Nature Materials* 12, 729-734 (2013).

21. Wonsuk Cha, Sanghoon Song, Nak Cheon Jeong, Ross Harder, Kyung Byung Yoon, Ian K Robinson, and Hyunjung Kim, Exploration of crystal strains using coherent x-ray diffraction, *New Journal of Physics* **12**, 035022 (2010).
22. Young-Joo Lee, Heeju Lee, Youngsuk Byun, Sanghoon Song, Je-Eun Kim, Daeyong Eom, Wonsuk Cha, Seong-Sik Park, Jinwoo Kim, Hyunjung Kim, Study of thermal degradation of organic light emitting device structures by X-ray scattering, *Thin Solid Films* **515**, 5674-5677 (2007).

■ Invited Presentations

1. Wonsuk Cha, Stephan Hruszkewycz, Rebecca Sichel-Tissot, Matthew J. Highland, Ross Harder, Wenjun Liu, Jörg Maser, Paul Fuoss, Three-dimensional Bragg Coherent Diffractive Imaging using Polychromatic X-rays, TMS 2015 144th Annual Meeting, Orlando, USA, Mar. 15, 2015 - Mar. 19, 2015.
2. Wonsuk Cha, Nak Cheon Jeong, Sanghoon Song, Hyun-jun Park, Tung Cao Thanh Pham, Ross Harder, Gang Xiong, Ian McNulty, Kyung Byung Yoon, Ian K. Robinson, Hyunjung Kim, Coherent X-ray Diffraction Study of Deformation Field Distribution inside Zeolite Crystals, The 24th Synchrotron Radiation User's Workshop, Pohang, Korea, Nov. 22, 2012.

■ Contributed the First Author Presentations (Talk)

1. Wonsuk Cha, Nak Cheon Jung, Sanghoon Song, Hyun-jun Park, Tung Cao Thanh Pham, Ross Harder, Bobae Lim, Gang Xiong, Docheon Ahn, Ian McNulty, Jungho Kim, Kyung Byung Yoon, Ian Robinson, Hyunjung Kim, Coherent X-ray Diffraction Imaging of Core-Shell Strain Structure in Zeolite Crystals, 2013 Fall Korean Physical Society Meeting, Changwon, Korea, Oct. 30, 2013 - Nov. 1, 2013.
2. Wonsuk Cha, Nak Cheon Jeong, Sanghoon Song, Hyun-jun Park, Tung Cao Thanh Pham, Ross Harder, Gang Xiong, Ian McNulty, Kyung Byung Yoon, Ian K. Robinson, Hyunjung Kim, Inhomogeneous Deformation Field Distribution Developed in a Zeolite Crystal by Coherent X-ray Diffraction Imaging, The 12th International Conference on Surface X-ray and Neutron Scattering, Kolkata, India, Jul. 25, 2012 - Jul. 28, 2012.
3. Wonsuk Cha, Sanghoon Song, Hyun-jun Park, Nak Cheon Jeong, Tung Cao Thanh Pham, Ross Harder, Gang Xiong, Ian McNulty, Kyung Byung Yoon, Ian K. Robinson, Hyunjung Kim, Coherent X-ray Diffraction Study of Unusual Deformation Field Distribution in Zeolites, 2012 Spring Korean Physical Society Meeting, Daejeon, Korea, Apr. 25, 2012 - Apr. 27, 2012.
4. Wonsuk Cha, Sanghoon Song, Hyun-jun Park, Nak Cheon Jeong, Tung Pham, Kyung Byung Yoon, Ross Harder, Gang Xiong, Ian K. Robinson, Hyunjung Kim, Inhomogeneous Deformation Field Distribution in Zeolite by Coherent X-ray Diffraction Imaging, The 1st Asia-Oceania conference on Neutron Scattering, Tsukuba, Japan, Nov. 20, 2011 - Nov. 24, 2011.
5. Wonsuk Cha, Sanghoon Song, Hyun-jun Park, Nak Cheon Jeong, Tung Pham, Kyung Byung Yoon, Ross Harder, Gang Xiong, Ian K. Robinson, Hyunjung Kim, Inhomogeneous Deformation Field Distribution in Zeolite Microcrystals, 2011 Fall Korean Physical Society Meeting, Busan, Korea, Oct. 19, 2011 - Oct. 21, 2011.

6. Wonsuk Cha, Sanghoon Song, Nak Cheon Jeong, Tung Pham, Ross Harder, Gang Xiong, Kyung Byung Yoon, Ian K. Robinson, Hyunjung Kim, Temperature Dependence of Internal Deformation Field in Zeolites, APS March Meeting 2011, Dallas, USA, Mar. 21, 2011 - Mar. 25, 2011.
7. Wonsuk Cha, Sanghoon Song, Nak Cheon Jeong, Kyung Byung Yoon, Ross Harder, Ian K. Robinson, Hyunjung Kim, Deformation Field Distribution of Zeolites Induced by Negative Thermal Expansion, 2009 Fall Korean Physical Society Meeting, Changwon, Korea, Oct. 21, 2009 - Oct. 23, 2009.
8. Wonsuk Cha, Sanghoon Song, Nak Cheon Jeong, Kyung Byung Yoon, Ross Harder, Ian K. Robinson, Hyunjung Kim, Strain Fields in Zeolite Microcrystals by Coherent X-ray Diffraction, APS March Meeting 2009, Pittsburgh, USA, Mar. 16, 2009 - Mar. 20, 2009.
9. Wonsuk Cha, Sanghoon Song, Nak Cheon Jeong, Kyung Byung Yoon, Ross Harder, Ian K. Robinson, Hyunjung Kim, Deformation Field Mapping of Zeolite Microcrystals by Coherent X-ray Diffraction, The 6th Workshop on Neutron and X-ray Scattering for Nano-Characterization, Pohang, Korea, Dec. 11, 2008 - Dec. 12, 2008.
10. Wonsuk Cha, Sanghoon Song, Nak Cheon Jeong, Kyung Byung Yoon, Ross Harder, Ian K. Robinson, Hyunjung Kim, Strain Field Mapping of Zeolite Microcrystals by Coherent X-ray Diffraction, 2008 Fall Korean Physical Society Meeting, Gwangju, Korea, Oct. 23, 2008 - Oct. 24, 2008.
11. Wonsuk Cha, Sanghoon Song, Nak Cheon Jeong, Kyung Byung Yoon, Ross Harder, Ian K. Robinson, Hyunjung Kim, Deformation Field Mapping of Zeolite Microcrystals by Coherent X-ray Diffraction, The 10th International Conference on Surface X-ray and Neutron Scattering, Paris, France, Jul. 2, 2008 - Jul. 5, 2008.

■ **Contributed the First Author Presentations (Poster)**

1. Wonsuk Cha, Stephan Hruszkewycz, Rebecca Sichel-Tissot, Matthew Highland, Ross Harder, Wenjun Liu, Jörg Maser, Paul Fuoss, Three-dimensional Bragg coherent diffraction imaging using polychromatic x-rays, International Workshop on Phase Retrieval and Coherent Scattering (Coherence 2014), Evanston, USA, Sep. 2, 2014 - Sep. 5, 2014.
2. Wonsuk Cha, Nak Cheon Jeong, Sanghoon Song, Hyun-jun Park, Tung Cao Thanh Pham, Ross Harder, Bobae Lim, Gang Xiong, Docheon Ahn, Ian McNulty, Jungho Kim, Kyung Byung Yoon, Ian K. Robinson, Hyunjung Kim, Core-Shell Strain Structure of Zeolite Microcrystals, Gordon Research Conference on X-ray Science, Easton, USA, Aug. 4, 2013 - Aug. 9, 2013.
3. Wonsuk Cha, Nak Cheon Jeong, Sanghoon Song, Hyun-jun Park, Tung Cao Thanh Pham, Ross Harder, Gang Xiong, Ian McNulty, Kyung Byung Yoon, Ian K. Robinson, Hyunjung Kim, Transient Deformation Field Distribution in Zeolite Crystals by Coherent X-ray Diffraction Imaging, The 5th Workshop on FEL Science, Kyoungju, Korea, Oct. 28, 2012 - Nov. 1, 2012.
4. Wonsuk Cha, Sanghoon Song, Hyun-jun Park, Nak Cheon Jeong, Ross Harder, Gang Xiong, Kyung Byung Yoon, Ian K. Robinson, Hyunjung Kim, Coherent X-ray Scattering Study of Internal Deformation Field Distribution of Zeolites, The 9th Workshop on X-ray and Neutron Scattering Technique for Nano-Characterization, Seoul, Korea, Dec. 8, 2011.

5. Wonsuk Cha, Sanghoon Song, Hyun-jun Park, Nak Cheon Jeong, Ross Harder, Gang Xiong, Kyung Byung Yoon, Ian K. Robinson, Hyunjung Kim, Coherent X-ray Scattering Study of Internal Deformation Field Distribution of Zeolites, Gordon Research Conference on X-ray Science, Waterville, USA, Aug. 7, 2011 - Aug. 12, 2011.
6. Wonsuk Cha, Sanghoon Song, Hyun-jun Park, Nak Cheon Jeong, Ross Harder, Gang Xiong, Kyung Byung Yoon, Ian K. Robinson, Hyunjung Kim, Coherent X-ray Scattering Study of Internal Deformation Field Distribution of Zeolites, Gordon Research Seminar on X-ray Science, Waterville, USA, Aug. 6, 2011 - Aug. 7, 2011.
7. Wonsuk Cha, Sanghoon Song, Nak Cheon Jeong, Kyung Byung Yoon, Ross Harder, Ian K. Robinson, Hyunjung Kim, Internal Strain Distribution of Zeolites by Coherent X-ray Diffraction, 2010 Prairie Section of the American Physical Society, Chicago, USA, Nov. 18, 2010 - Nov. 20, 2010.
8. Wonsuk Cha, Hyun-jun Park, Sanghoon Song, Nak Cheon Jeong, Kyung Byung Yoon, Ross Harder, Ian K. Robinson, Hyunjung Kim, Calcination Process Dependence of Deformation Field Distribution in Zeolite Crystal, 2010 Fall Korean Physical Society Meeting, Pyoungchang, Korea, Oct. 20, 2010 - Oct. 22, 2010.
9. Wonsuk Cha, Sanghoon Song, Nak Cheon Jeong, Ross Harder, Kyung Byung Yoon, Ian K. Robinson, Hyunjung Kim, Internal Strain mapping of Zeolite Microcrystals by Coherent X-ray Diffraction Imaging, The 10th international conference on x-ray microscopy, Chicago, USA, Aug. 15, 2010 - Aug. 20, 2010.
10. Wonsuk Cha, Sanghoon Song, Nak Cheon Jeong, Kyung Byung Yoon, Ross Harder, Ian K. Robinson, Hyunjung Kim, Exploration of zeolite crystal strains using coherent x-ray diffraction, The 11th International Conference on Surface X-ray and Neutron Scattering, Evanston, USA, Jul. 13, 2010 - Jul. 17, 2010.
11. Wonsuk Cha, Sanghoon Song, Nak Cheon Jeong, Kyung Byung Yoon, Ross Harder, Ian K. Robinson, Hyunjung Kim, Binder Density Dependence of Internal Strain Distribution in ZSM-5 Microcrystals, 2010 Spring Korean Physical Society Meeting, Daejeon, Korea, Apr. 21, 2010 - Apr. 23, 2010.
12. Wonsuk Cha, Sanghoon Song, Nak Cheon Jeong, Kyung Byung Yoon, Hyunjung Kim, Ross Harder, Ian K. Robinson, Imaging of Zeolite Crystals by Coherent X-ray Diffraction, 2010 Winter Korean Optical Society Meeting, Gwangju, Korea, Jan. 20, 2010 - Jan. 22, 2010.
13. Wonsuk Cha, Sanghoon Song, Nak Cheon Jeong, Kyung Byung Yoon, Ross Harder, Ian K. Robinson, Hyunjung Kim, Mapping of deformation field in zeolites by coherent x-ray diffraction, The 20th International Conference on Molecular Electronics and Devices, Seoul, Korea, May 22, 2009 - May 23, 2009.
14. Wonsuk Cha, Sanghoon Song, Nak Cheon Jeong, Kyung Byung Yoon, Ross Harder, Ian K. Robinson, Hyunjung Kim, Coherent X-ray Diffraction Imaging of Zeolites Crystals, Workshop on Seoul Nano-Bio Innovation Cluster and Industrial-Educational Cooperation, Seoul, Korea, May 16, 2009.
15. Wonsuk Cha, Sanghoon Song, Nak Cheon Jeong, Kyung Byung Yoon, Ross Harder, Ian K. Robinson, Hyunjung Kim, Phase Retrieval Algorithm in Coherent X-ray Diffraction Imaging, 2009 Spring Korean Physical Society Meeting, Daejeon, Korea, Apr. 23, 2009 - Apr. 24, 2009.
16. Wonsuk Cha, Sanghoon Song, Nak Cheon Jeong, Kyung Byung Yoon, Ross Harder, Ian K. Robinson, Hyunjung Kim, Coherent X-ray Diffraction Study of Strain Field Mapping

- in Zeolite Microcrystals, The 1st Workshop on FEL Science, Jeju, Korea, Feb. 16, 2009 - Feb. 18, 2009.
17. Wonsuk Cha, Sanghoon Song, Nak Cheon Jeong, Kyung Byung Yoon, Ross Harder, Ian K. Robinson, Hyunjung Kim, Coherent X-ray Diffraction Imaging of Zeolite Microcrystals, The 3rd IUPAP International Conference on Women in Physics 2008, Seoul, Korea, Oct. 8, 2008 - Oct. 10, 2008.
 18. Wonsuk Cha, Sanghoon Song, Nak Cheon Jeong, Kyung Byung Yoon, Ross Harder, Ian K. Robinson, Hyunjung Kim, 3D Imaging of Zeolite Single Crystals by Using Coherent X-ray Diffraction, 2008 Spring Korean Physical Society Meeting, Daejeon, Korea, Apr. 17, 2008 - Apr. 18, 2008.
 19. Wonsuk Cha, Hyunjung Kim, X-ray Scattering Study of Organic Films by Organic Molecular Beam Deposition, 2007 Fall Korean Physical Society Meeting, Jeju, Korea, Oct. 18, 2007 - Oct. 19, 2007.

■ Award

1. Best Poster Presentation Award, co-author, 2015 Fall Korean Physical Society Meeting, Oct. 22, 2015.
2. Excellent Poster Presentation Award, co-author, 2014 Spring Korean Physical Society Meeting, Apr. 25, 2014.
3. AsCA Early Career Travel Award, The 1st author, The 12th Meeting of the Asian Crystallographic Association, Dec. 7, 2013.
4. Excellent Paper Award for Graduate Student, The Korean Synchrotron Radiation User's Association, Nov. 21, 2013.
5. Excellent Oral Presentation Award, The 1st author, 2012 Spring Korean Physical Society Meeting, Apr. 27, 2012.
6. Excellent Poster Presentation Award, The 1st author, 2010 Brain Korea 21 Workshop, Aug. 25, 2010.
7. Excellent Poster Presentation Award, The 1st author, 2010 Spring Korean Physical Society Meeting, Apr. 23, 2010.
8. Excellent Paper Presentation Award, The 1st author, 2010 Winter Korean Optical Society Meeting, Jan. 21, 2010.
9. Best Oral Presentation Award, co-author, 2009 Fall Korean Physical Society Meeting, Oct. 23, 2009.
10. Excellent Poster Presentation Award, The 1st author, 2009 Spring Korean Physical Society Meeting, Apr. 23, 2009.
11. Excellent Poster Presentation Award, Co-author, In situ study of the formation of membrane proteins in lipid bilayers by x-ray reflectivity, 2009 Spring Korean Physical Society Meeting, Apr. 23, 2009.
12. Excellent Poster Presentation Award, The 1st author, 3D Imaging of Zeolite Single Crystals by Using Coherent X-ray Diffraction, 2008 Spring Korean Physical Society Meeting, Apr. 17, 2008.
13. Excellent Poster Presentation Award, Co-author, Characterization of Surface and Pore Morphologies on Nanoporous Organosilicate Films, 2008 Spring Korean Physical Society Meeting, Apr. 17, 2008.

■ Major Accomplishments

- Utilizing broadband x-rays for Coherent X-ray Diffraction Imaging in Bragg geometry

Coherent x-ray diffraction imaging in the Bragg geometry is a powerful technique to examine internal strain distributions of crystals in nanoscale. Currently the method has technical limitations. An isolated crystal must be rotated in a tiny x-ray beam to collect three-dimensional datasets. However, because it takes longer than several minutes to acquire a dataset, this technique is limited for fast measurements. In addition, it is challenging to position crystals in nanoscale on the center or rotation of stages within the focused small beam.

As a postdoctoral appointee in Materials Science Division, Argonne National Laboratory, I am working to overcome these challenges and demonstrate new approaches for Bragg coherent x-ray diffraction imaging that utilize broadband x-rays from state of the art synchrotron sources. I led the development and design of two successful experimental approaches that explore this concept. First, I built a test-bed diffractometer system based on the concept of post-sample monochromatization of a polychromatic Bragg reflection. The basic concept of this approach is to disperse diffracted polychromatic x-rays by angle and wavelength with an array of semi-transparent single crystal analyzers. With this multi-plexing setup we obtained three-dimensional reciprocal space maps during the ferroelectric-to-paraelectric phase transition in a PbTiO_3 thin film on a DyScO_3 substrate with sub-second time resolution without rotating the sample. I aim to extend this approach to coherent diffraction imaging in the coming years.

In parallel to this thrust, I developed a new phase retrieval algorithm that enables three-dimensional coherent Bragg diffraction imaging with variable-energy scans. This approach compensates for different pixel spacing in reciprocal space for different energy of x-rays and produces comparable results to traditional Bragg coherent x-ray diffraction imaging without requiring any sample movement. These results demonstrate a capability critical to extending coherent diffraction imaging to complex materials science problems, such as the sample under mechanically forced or poly-grained crystalline materials, in which precision sample rotation is cumbersome or impossible. Together, multi-analyzer and variable-energy coherent x-ray diffraction imaging will open the door to major new breakthroughs in nanoscale materials strain imaging under realistic environments.

- First measurement of polymer dynamics with X-ray Photon Correlation Spectroscopy at the Linac Coherent Light Source

Hard x-ray free electron lasers which produce brilliant and fully coherent x-rays are now available that open new areas of science, especially in condensed matter systems, over a range of times scales from femtoseconds to seconds. However beam damage and beam induced effects such as sample heating are major issues that can complicate hard x-ray free electron laser experiments. To better characterize this effect, I was part of a team that used x-ray photon correlation spectroscopy to measure slow dynamics in a polymer undergoing x-ray induced structural changes at the Linac Coherent Light Source. We obtained relaxation time constants from polymers as a function of wavevector transfer using speckle correlation methods. We also observed different regimes of relaxation due to sample aging. This work reveals beam dose and flux limits that are critical to the design of future hard x-ray free electron lasers experiments, especially for soft material studies.

- In-situ materials science with Bragg Coherent X-ray Diffraction Imaging

Catalysts, and other electrochemically active materials often perform optimally in nano- and micro-scale crystals and transform in complex ways during functioning. Throughout my career, one of my primary research thrusts has been to use Bragg coherent x-ray diffraction imaging to reveal the local details of these structural transformations under working conditions.

For example, zeolites, defined as crystalline aluminosilicates, are widely used as catalysts, ion-exchangers, molecular separation membranes and many other applications because of naturally-occurring three-dimensional networks of internal pores and channels. However, the shape and the size of these channels can be distorted when zeolites are strained. This, in turn, decreases the rates of adsorption of molecules into zeolites, the diffusion within channels, and the desorption from the channels, affecting materials performance and utility.

As a part of my Ph.D. thesis work, I investigated this issue by using in-situ coherent x-ray diffraction imaging. Individual crystals annealed at relatively low temperature show unique strain distributions, whereas ones annealed at higher temperature do not. With these results, in combination with other microscopy and finite element modeling, I discovered that the presence of minute amount of residual organic template, which is essential in synthesizing highly crystalline zeolites remained in the crystals. This was evident from different thermal expansion behavior in the core of the material which introduces a distortion of the zeolite crystal lattice.

More recently, I have worked with my group from ANL-MSD to conduct in-situ Bragg coherent x-ray diffraction imaging studies of palladium hydriding and silver dissolution that successfully imaged individual nanoparticles undergoing radical changes in morphology and internal strain state. These studies revealed the importance of dislocation distributions in local activity, and they shed new light as to the local mechanisms that drive average behavior in transforming materials. In addition, I also participate in the project on platinum catalysts to image strain evolutions when catalytic reactions occur. The results will allow us to demonstrate mechanisms of catalytic reactions.